Physics 108 - Cosmology   Homework 3

1. Air turbulence and changes in temperature and pressure cause the light to bend, which makes The stars appear larger than they really are, and rapid changes (especially due to wind and air currents and turbulence) cause The image to change, which looks like twinkling.

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2. Several reasons:

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i) When light is reflected from a mirror it does not undergoe dispersion, which refracts different wavelengths by different amounts

ii) Mirrors can be lighter than lenses

iii) Mirrors are easier to prepare than lenses, because you only have to polish one surface.

iv) Some kinds of light (infrared and ultraviolet) are absorbed by some kinds of glass,

v) If the mirrors are somewhat flexible then it is possible to deform them slightly to adjust the optics for changes in temperature, weight of the mirror itself, and air turbulence ("adaptive optics")

Any one of these is sufficient.

3. Several reasons:

i) The higher they are, the less air above to cause problems with "seeing" (see homework question 1).

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ii) very high mountains can be above moisture and some clouds, which improves "seeing"

iii) they are then (usually) away from the extra light caused by cities ("light pollution")

4. To compute the escape speed we need the mass and radius of the moon. From Wikipedia

$$M_☾ = 7.35 \times 10^{22} \text{ kg}$$

$$R_☾ = 1.74 \times 10^{6} \text{ m}$$

(I expected this to be in our textbook. Sorry.)

a) The escape speed is

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$$V = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{(6.67\times10^{-11})(7.35\times10^{22})\,2}{1.74\times10^{6}}}$$

$$= 2374 \text{ m/s} \approx 2400 \text{ m/s}$$

b) For a simple estimate simply compute the horizontal speed

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$$V = \frac{250\,m}{5\,s} = 50\ m/s$$

The golf ball will also have a vertical component, but it won't be any bigger than this, so as a rough estimate use 50 to 100 m/s.

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c) No way. 50 m/s or even 100 m/s is not anywhere near 2400 m/s, the speed needed to leave the moon.

5. The mass of the Sun and Earth are in the front of the book. Use $M_{☾}$ as above

a) The moon's orbital radius is about 384,400 km $= 3.84 \times 10^8\ m$, (from Chapter 8)

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So $$F = \frac{G M_{☾} M_{\oplus}}{d^2} = \frac{(6.67\times10^{-11})(7.35\times10^{22}\,kg)(5.97\times10^{24})}{(3.84\times10^{8})^2}$$

$$= 1.98 \times 10^{20}\ \text{Newtons}$$

5b) During the new moon the moon is in front of the Earth, so the distance between them is the Earth-Sun distance, minus the orbital radius of the moon

$$d = 1.496 \times 10^{11} \text{ m} - 3.84 \times 10^{8} \text{ m}$$

$$= 1.492 \times 10^{11} \text{ m}$$ (very little difference)

$$F = \frac{G M_\odot M_☾}{d^2} = \frac{(6.67 \times 10^{-11})(1.989 \times 10^{30} \text{ kg})(7.35 \times 10^{22} \text{ kg})}{(1.492 \times 10^{11} \text{ m})^2}$$

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$$= 4.38 \times 10^{20} \text{ Newtons}$$

c) The force of attraction of the Sun on the Moon is larger than the force due to the Earth, by

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$$\frac{4.38 \times 10^{20} \text{ N}}{1.98 \times 10^{20} \text{ N}} = 2.2 \simeq 2 \text{ times larger}$$

d) At full moon $d = 1.496 \times 10^{11} + 3.84 \times 10^{8}$ meters

$\doteq 1.4998 \times 10^{11}$ meters, Then the force is

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$F = 4.33 \times 10^{20}$ N just a little bit weaker

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